इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 7931-1 (1975): Automatic and semi-automatic welding equipment with self-adjusting arcs (MIG/MAGprocesses): Part 1 dc welding generator power source [ETD 21: Electric Welding Equipment]

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

Made Available By
Public.Resource.Org

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE

BRUTUM FULMEN
IGNORANTIA JURIS NON EXCUSAT
PROTECTED BY COPYRIGHT

IS : 7931 (Part I) - 1975

(Reaffirmed 2004)

Indian Standard

SPECIFICATION FOR AUTOMATIC AND SEMI-AUTOMATIC WELDING EQUIPMENT WITH SELF-ADJUSTING ARCS (MIG/MAG PROCESSES)

PART I DC WELDING GENERATOR POWER SOURCE

(First Reprint MAY 1986)

UDC 621.791.75.03:621.313.2

© *Copyright* 1976

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5

April 1976

Indian Standard

SPECIFICATION FOR AUTOMATIC AND SEMI-AUTOMATIC WELDING EQUIPMENT WITH SELF-ADJUSTING ARCS (MIG/MAG PROCESSES)

PART I DC WELDING GENERATOR POWER SOURCE

Electric Welding Equipment Sectional Committee, ETDC 21

Chairman	*Representing*
SHRI J. A. MULIYIL	Indian Oxygen Ltd, Calcutta
Members	
SHRI A. C. LAHIRI (*Alternate* to Shri J. A. Muliyil)	
ASSISTANT DIRECTOR, WEAPON EQUIPMENT (UNDER-WATER EQUIPMENT)	Naval Headquarters
STAFF OFFICER (WEAPON EQUIPMENT) (*Alternate*)	
SHRI S. BHATIA	Philips India Ltd, Bombay
SHRI H. D. CHICKERMANE (*Alternate*)	
SHRI P. COOMAR	Sur Iron & Steel Co Pvt Ltd, Calcutta
SHRI P. K. NEOGI (*Alternate*)	
SHRI K. L. GARG	Directorate General of Supplies & Disposals (Inspection Wing), New Delhi
SHRI V. S. KRIPALANI (*Alternate*)	
SHRI SUDHIR KUMAR HARI	Malik Electricals (Private) Ltd, Bombay
SHRI KESHAR SINGH	Triveni Structurals Ltd, Allahabad
SHRI S. K. CHAUDHARY (*Alternate*)	
SHRI N. K. MATHUR	Bharat Heavy Electricals Ltd, Bhopal
LT-COL N. I. K. MURTHY	Department of Defence Production, Directorate of Standardization, Ministry of Defence
SHRI V. S. SUGUR (*Alternate*)	
SHRI G. T. NIHALANI	Advani-Oerlikon Private Ltd, Bombay
SHRI J. K. CHANDNA (*Alternate*)	
SHRI T. A. RAMACHANDRAN	Railway Board, Ministry of Railways
SHRI D. KALYANASUNDARAM (*Alternate*)	
SHRI H. L. ROBERTS	Mazagon Dock Ltd, Bombay
SHRI M. K. SRIDHAR	Bharat Heavy Electricals Ltd, Tiruchirapalli
SHRI M. A. KESAVAN (*Alternate*)	

(*Continued on page* 2)

© *Copyright* 1976
INDIAN STANDARDS INSTITUTION
This publication is protected under the *Indian Copyright Act* (XIV of 1957) and reproduction in whole or in part by any means except with written permission of the publisher shall be deemed to be an infringement of copyright under the said Act.

(*Continued from page* 1)

Members	*Representing*
Shri N. S. Subbanna	Kirloskar Electric Co Ltd, Bangalore
Shri M. Gurubaswaraj (*Alternate*)	
Shri N. Srinivasan, Director (Elec tech)	Director General, ISI (*Ex-officio Member*)

Secretary

Shri N. Dassharma
Deputy Director (Elec tech), ISI

Indian Standard

SPECIFICATION FOR AUTOMATIC AND SEMI-AUTOMATIC WELDING EQUIPMENT WITH SELF-ADJUSTING ARCS (MIG/MAG PROCESSES)

PART I DC WELDING GENERATOR POWER SOURCE

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 30 December 1975, after the draft finalized by the Electric Welding Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 There are numerous variations of arc welding processes using consumable electrode wires. The wire may be solid or composite, and with or without flux. In all these cases, the melting generally takes place in the presence of a shielding gas. This gas may be inert (for example, argon) or have a definite chemical activity at the high temperature of the electric arc (for example, carbon dioxide). When the shielding gas is inert the welding process is known as MIG process and when this gas has a definite chemical activity at the high temperature of the electric arc, this process is called MAG process.

0.3 This standard on automatic and semi-automatic welding equipment is being issued in three parts. This part covers dc welding generators power sources while transformer-rectifier power sources are covered in Part II and welding gun and ancillary equipment in Part III.

0.4 In preparing this standard, assistance has been derived from the following:

ISO Doc TA-76/72/E Specification of arc-welding equipment using consumable wires (MIG/MAG processes).

Document No. 71/42369 — Draft British Standard Specification for arc welding plant, equipment and accessories (*revision of* BS : 638-1966). British Standards Institution.

NEMA EW-1-1971 Electric arc-welding apparatus. National Electrical Manufacturers' Association, USA.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part I) lays down the requirements, tests and service conditions for dc arc welding generator power source having a substantially flat load characteristic for semi-automatic and automatic arc welding with self-adjusting arcs (MIG/MAG processes).

1.2 The windings of generator covered by this standard are of insulation classes A, E, B, F and H.

1.3 Welding generators covered by this standard are assigned ratings on the basis of duty cycle.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Generator Power Source — A direct current generator with associated reactors, control and indicating devices required to produce direct current for arc welding.

2.2 Semi-Automatic Welding — Metal arc welding in which the arc length is automatically controlled but the positioning of the arc is manual.

2.3 Automatic Welding — Metal arc welding in which the arc length and the travel of the electrodes or the work pieces are automatically controlled.

2.4 Self-Adjusting Arc Welding — Metal arc welding in which the electrode is fed at a constant speed while the arc length is maintained substantially constant by the inherent electrical characteristics of the welding current circuit.

2.5 Partially Self-Adjusting Arc Welding — Metal arc welding in which the inherent tendency towards equilibrium between burn off rate and wire feed speed is supplemented by other means.

2.6 Protected Plant — Power source in which internal live or rotating parts are protected mechanically from accidental or inadvertent contact, whilst ventilation is not materially impeded.

---

*Rules for rounding off numerical values (*revised*).

2.7 Drip-Proof Plant — Protected power source in which the openings for ventilation are so protected as to exclude vertically falling water or dirt.

2.8 Screen Protected Plant — A protected power source in which all the ventilating openings in the frame and/or end shields are protected with wire screen, expanded metal or other suitable perforated covers having aperture not exceeding 325 mm^2 in area, but not less than 60 mm^2 in area.

2.9 Rating — A statement of the operating characteristics assigned to the welding power source by the manufacturer, when tested under specified conditions.

2.10 Welding Load Current — Current delivered by the welding power source on a practically non-inductive resistance load.

2.11 Welding Load Voltage — The voltage between the output terminals of a power source (the terminals to which the electrode and return leads are connected) when a specified current is flowing through a resistance load.

2.12 Load Characteristic — The specified relationship between welding load voltage and load current of a welding power source.

2.13 Maximum Continuous Automatic Welding Current — The maximum welding current which is to be supplied by the power source for continuous operation on automatic welding at the specified voltage and duty cycle.

2.14 Maximum Continuous Semi-Automatic Welding Current — The maximum welding current which is supplied by the power source for continuous operation on semi-automatic welding at the specified voltage and duty cycle.

2.15 Maximum Automatic Welding Current — The maximum automatic welding current, the welding power source is capable of delivering at the specified load voltage, for intermittent use specified by the manufacturer.

2.16 Maximum Semi-Automatic Welding Current — The maximum semi-automatic welding current, the welding power source is capable of delivering at the specified load voltage, for intermittent use specified by the manufacturer.

2.17 Duty Cycle — The ratio of time during which the power source is loaded to the total elapsed time during one welding cycle.

2.18 Open-Circuit Voltage — The voltage between the output terminals (that is, those to which the electrode and return leads are connected) of a welding plant ready to weld but carrying no welding current.

2.19 Type Tests — Tests carried out to prove conformity with the specification. These are intended to prove the general qualities and design of a welding power source.

2.20 Routine Tests — Tests carried out on each welding power source to check requirements which are likely to vary during production.

2.21 Slope of the Volt-Ampere Characteristic — The slope of the static volt-ampere curve is the ratio of output voltage change to the change in output current expressed in volts per 100 amperes.

3. RATING

3.1 Rated Open-Circuit Voltage — The open-circuit voltage of the welding generator shall not exceed 100 volts.

3.2 Rated Current — The welding generator shall be rated at currents at duty cycle corresponding to maximum continuous semi-automatic welding current and maximum continuous automatic welding current. Preferred current ratings shall be 150, 200, 250, 300, 400, 500, 600 and 800A.

3.3 Maximum Continuous Automatic Welding Current — The maximum continuous automatic welding current rating shall be that corresponding to 100 percent duty cycle.

3.4 Maximum Continuous Semi-Automatic Welding Current — The maximum continuous semi-automatic welding current rating shall be that corresponding to 85 percent duty cycle. This comprises a complete cycle consisting of 4·25 minutes under the load condition followed by a period of 0·75 minute of no-load operation.

4. MARKING

4.1 Rating Plate Information — The following information shall be given on the rating plates:

a) Manufacturer's name and/or trade-mark;
b) Manufacturer's type designation and serial number;
c) Maximum continuous automatic current/Maximum continuous semi-automatic current;
d) Maximum semi-automatic current/Maximum automatic current;
e) Maximum open circuit voltage;
f) Speed at the rated current;
g) Insulation class;
h) Maximum input power required for prime-mover in kW; and

j) A warning as follows:

‘ *Warning* — Currents in excess of the following are for intermittent use only:

1) for semi-automatic welding ......A.
2) for automatic welding ......A. ’

4.2 Terminal Marking

4.2.1 *Output Terminals* — If polarity changeover switch is not provided, output terminals shall be prominently marked in relation to their polarity.

4.2.2 Positive terminal shall be marked ‘ + ’.

4.2.3 Negative terminal shall be marked ‘ — ’.

4.3 Direction of Rotation — When the generator is suitable for operation at rated load in one particular direction only, this direction of rotation shall be indicated prominently on the body of the generator.

4.4 The welding generators may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

5. GENERAL REQUIREMENTS

5.1 Enclosure — It is recommended that the minimum standard of enclosure for generator power sources should be drip-proof.

5.2 Earthing — Two earthing terminals shall be provided for two separate and distinct connections to earth of all metallic parts which are not intended to carry current. Earthing terminals shall be indelibly marked with the symbol ‘ ⏚ ’. Earthing terminals shall be suitably protected against corrosion and shall be metallically clean.

5.3 Internal Combustion Engines for Driving Generators

5.3.1 Internal combustion engines for driving dc generators shall comply with the relevant Indian Standards.

5.3.2 For semi-automatic welding, the one-hour rated kilowatt shall exceed the power required for the maximum continuous semi-automatic welding current rating and corresponding load voltage for which the generator is calibrated by at least 10 percent.

For automatic arc welding, the 12-hour rated kilowatt shall exceed the power required for the maximum continuous automatic welding current by at least 10 percent.

5.3.3 De-rating for site condition shall be as agreed to between the purchaser and the supplier.

5.3.4 The rated speed of an IC engine shall correspond to the generator speed required to deliver the semi-automatic welding current and corresponding load voltage given in **6.5**.

5.3.5 Speed regulation under automatic speed control of an IC engine measured as the difference between rated speed and no-load speed, under steady load conditions, shall not exceed 10 percent of rated speed.

5.4 Electric Motors for Driving DC Generators

5.4.1 Motors coupled to the generator shall conform to IS : 325-1970*.

5.4.2 Rating of the motor shall be in accordance with the requirements of generator at its maximum continuous automatic welding current at 100 percent duty cycle or maximum continuous semi-automatic welding current at 85 percent duty cycle depending on which is higher.

5.4.3 The inherent speed regulation of an electric motor measured as the difference between speed on no load and speed when driving the generator at maximum continuous semi-automatic welding current and corresponding load voltage shall not exceed 10 percent of the rated speed.

6. TESTS

6.0 Tests shall be made to prove compliance with all the requirements of this standard.

6.1 Type Tests — These tests may be carried out by mutual agreement between the purchaser and the supplier and if the records of type test on a dc electric welding generator which in essential details is representative of the one being purchased, are furnished the purchaser may accept this as evidence of type test instead of actual tests. Type tests and their sequence shall be as follows:

a) Insulation resistance test (*see* **6.3**),

b) No-load test (*see* **6.4**),

---

*Specification for three-phase induction motors (*third revision*).

c) Load test (*see* **6.5**),

d) Temperature-rise test (*see* **6.6**),

e) Commutation test (*see* **6.7**),

f) High voltage test (*see* **6.8**), and

g) Insulation resistance test (repeat) (*see* **6.3**).

6.2 Routine Tests — Routine tests and their sequence shall be as follows:

a) Insulation resistance test (*see* **6.3**),

b) No-load test (*see* **6.4**),

c) Load test (*see* **6.5**),

d) Commutation test (*see* **6.7**),

e) High voltage test (*see* **6.8**), and

f) Insulation resistance test (repeat) (*see* **6.3**).

6.2.1 A certificate of routine tests shall be furnished by the manufacturer which shall show that each of the welding generators has been subjected to the tests specified in **6.2** and that it complies with the requirements specified in this standard for these tests and that each of the welding generator has been found to be sound electrically and mechanically and is in working order in all particulars.

6.3 Insulation Resistance Test — The insulation resistance shall be measured with a dc voltage of about 500 volts applied for a sufficient time for the reading of the indicator to become practically steady, such voltage being taken from an independent source or generated in the measuring instrument. The insulation resistance shall be not less than one megohm.

NOTE — A very high value of insulation resistance in megohms is not specified for generators, as in order to obtain it long baking at high temperature may be necessary and this may permanently damage the insulating material.

6.4 No-Load Test — With the generator running and output terminals open-circuited, the following shall be measured:

a) Open-circuit voltage, and

b) Speed at no-load.

6.5 Load Test

6.5.1 The associated load currents and load voltages are measured at the output terminals of the generator through a resistive load. The values of welding current and associated voltages shall be as agreed to between the manufacturer and the purchaser. For general guidance the associated load currents and load voltages shall be given by the following equation:

$$U_2 = 14 + 0{\cdot}05\ I_2$$

where

U_2 = welding load voltage, and
I_2 = corresponding value of the welding current.

6.5.2 *Tolerance* — The permissible tolerances for rated values of current shall be ±10 percent and for the declared values of maximum open-circuit voltage, the variation permitted shall be ±5 percent.

6.6 Temperature-Rise Test

6.6.1 *Test Conditions*

6.6.1.1 The load should be a non-inductive resistance, and at the appropriate load voltage. A tolerance of ±10 percent should be allowed on the value of this load voltage.

6.6.1.2 Welding generators shall be tested for temperature-rise (*see* Appendix A) at a current equal to the maximum continuous automatic welding current and at a duty cycle equal to 100 percent.

6.6.1.3 If the generator is for semi-automatic welding only, it shall be tested at an equivalent continuous maximum welding current arrived at by using the formula:

$$\text{Maximum continuous automatic welding current} = 0{\cdot}92 \times \text{maximum semi-automatic welding current}$$

6.6.1.4 The temperature-rise of a generator when tested under specified conditions shall not exceed the limits given in Table 1.

6.6.2 *Conditions During Temperature-Rise Test*

6.6.2.1 *Ambient temperature* — The generator may be tested at any convenient value of ambient temperature not exceeding 40°C.

6.6.2.2 *Measurement of ambient temperature during tests* — The value to be adopted for the ambient temperature during a test shall be the mean of the readings of the thermometers taken at equal intervals of time during the last quarter of the duration of the test.

In order to avoid errors due to the time lag between the temperature of large generators and the variations in the ambient temperature, all reasonable precautions shall be taken to reduce these variations and the errors arising therefrom.

The ambient air temperature shall be measured by means of several thermometers placed at different points around and half way up the generator at a distance of one or two metres, and protected from all heat radiation and draughts.

6.6.2.3 *Correction of measurements taken after the generator has come to rest*

a) In case the temperature can be measured only after the generator has come to rest the cooling curve is plotted by determining the first points as rapidly as possible. Two possibilities may arise:

  1) If the part considered cools down evenly from the moment of shutdown, the maximum temperature measurable at the end of the test may be deduced by extrapolation of the cooling curve.

  2) If after shutdown successive measurements reveal temperatures that increase first only to decrease later, the extrapolation laid down above becomes inapplicable. It is then accepted that the maximum observable temperature is the highest temperature measured, except if in the vicinity of the measuring points there are other points of the same part for which a higher temperature-rise than at the measuring point is permissible. In this latter case, it is sufficient to take the first of the readings which have been taken.

b) The resistance method may be used on generators with one coil side per slot, if the generator comes to a standstill as quickly as possible. In the case of generators with considerable inertia, the extrapolation method should only be used by agreement between the manufacturer and the purchaser.

6.6.2.4 *Temperature corrections for altitudes* — Temperature corrections for altitude shall be made in accordance with Appendix B.

6.6.3 *Limits of Temperatures and Temperature-Rise*

6.6.3.1 *Temperature-rises* — Table 1 gives the limits of permissible temperature-rise above the ambient temperature for generator of insulation Classes A, E, B, F and H.

For Class C materials, no limits of temperature-rise have yet been assigned.

6.7 Commutation Test

6.7.1 Generators rated in accordance with this standard shall operate with practically sparkless commutation for all duties at currents throughout the range of the generator.

6.7.2 A special test to check the quality of commutation shall be made by subjecting the generator to 150 percent of the maximum automatic welding current or maximum semi-automatic welding current, whichever is higher, for 15 seconds. During this period, there should not be injurious sparking nor damage to the commutator.

6.7.3 When carried out as a type test the test shall be made after the temperature-rise test when the commutator has attained stable temperature under rated condition.

6.8 High Voltage Test

6.8.1 *Test Conditions* — High voltage test shall be carried out at a test voltage equal to 1 000 + 2 U_R with a minimum of 2 000 V, where U_R is the rated voltage. The test voltage shall be applied between the windings and the frame of the generator with the core connected to the frame and to the windings not under test. The high voltage test shall be applied once and only once to a new and completed generator in normal working condition, with all its parts in place, and shall be carried out together with the insulation resistance test at the conclusion of the tests laid down in this standard at the manufacturer's works.

6.8.2 *Method of High Voltage Test* — The test shall be made with alternating voltage of any convenient frequency between 40 to 60 Hz. The test voltage shall be of approximately sine-wave form; and during the application of the test voltage, the peak value, as would be determined by spark gap, by oscillograph or by any other approved method, shall not be more than 1·45 times the rms value. The rms value of the applied voltage shall be measured by a suitable voltmeter connected to the output side of the testing transformer, by means of a voltmeter used with a suitable calibrated potential transformer or by means of a voltmeter winding on the testing transformer.

The test shall be commenced at a voltage of about one-third the test voltage which shall be increased to the full test voltage, specified in **6.8.1** as rapidly as is consistent with its value being indicated by the measuring instrument. The full test voltage shall then be maintained for one minute. At the end of the minute, the test voltage shall be rapidly diminished to one-third of its full value before switching off.

6.8.3 *Supplementary High Voltage Tests* — When for any reason, it is desired to make additional high voltage tests on a generator which has already passed the test in accordance with **6.8.1** and **6.8.2** and is installed on site, such additional high voltage test shall be made in accordance with **6.8.1** and **6.8.2** except that the test voltage shall be 75 percent of the value specified therein. Before applying the supplementary high voltage test, the windings shall be cleaned and the generator shall be thoroughly dried up.

TABLE 1 LIMITS OF TEMPERATURE-RISE IN °C

(*Clauses* 6.6.1.4 *and* 6.6.3.1)

SL No.	PART OF GENERATOR	CLASS OF INSULATION									
		Class A		Class E		Class B		Class F		Class H	
		T	*R*	*T*	*R*	*T*	*R*	*T*	*R*	*T*	*R*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1.	a) Field windings having dc excitation other than those in Sl No. 2 b) Windings of armatures having commutators	50	60	65	75	70	80	85	100	105	125
2.	a) Low-resistance field windings of more than one layer, and compensating windings	60	60	75	75	80	80	100	100	125	125
	b) Single-layer windings with exposed bare surfaces or varnished metal	65	65	80	80	90	90	110	110	135	135
3.	Magnetic core and other parts not in contact with windings	The temperature-rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts									
4.	Magnetic core and other parts in contact with windings	60	—	75	—	80	—	100	—	125	—
5.	Commutators and slip-rings* open or enclosed	60	—	70	—	80	—	90†	—	100†	—

T = by thermometer

R = by resistance

*The temperature-rises in Sl No. 5 are permissible provided that insulation appropriate to the temperature-rise is used, except where the commutator or slip-ring is adjacent to windings in which case the temperature-rise should not exceed that for the winding insulation class. The values of temperature-rises given apply only to the measurements made by bulb type thermometers.

†Special precautions may be necessary in using temperature-rises of 90°C and 100°C in the choice of brush grades and the like.

APPENDIX A

(*Clause* 6.6.1.2)

TEMPERATURE MEASUREMENT

A-1. METHODS OF MEASUREMENT OF TEMPERATURE-RISE

A-1.1 Temperature-Rise of a Part of a Generator — The temperature-rise of a part of a generator is the difference in temperature between that part of the generator measured by the appropriate method in accordance with **A-1.3** to **A-1.6** and the ambient measured in accordance with **6.6.1.1** and **6.6.1.2**.

A-1.2 Methods of Measurement of Temperatures — The following two methods of determining the temperature of windings and other parts are recognized:

a) Thermometer method, and

b) Resistance method.

A-1.2.1 For field windings and stator windings of generator or generator having only one coil-side per slot, the preferred method is the increase of resistance of windings.

A-1.2.2 The thermometer method is applicable in the cases when the resistance method is not applicable.

The employment of the thermometer method is also recognized in the following cases:

a) When it is not practicable to determine the temperature-rise by the resistance method, as for example, with low-resistance commutating coils and compensating windings, and, in general in the case of low-resistance windings, especially when the resistance of joints and connections forms a considerable portion of the total resistance.

b) Single-layer windings revolving or stationary.

c) When for reasons of manufacture in quantity, the thermometer method is used alone, although the resistance method may be possible.

NOTE — It is not intended that measurements by both thermometer method and the resistance method shall be required, and the figures of temperature-rise given in Table 1 for the thermometer method and the resistance method are not to be used as a check against one another.

If the purchaser wishes to have a thermometer reading taken in addition to the values determined by the resistance method, the temperature-rise determined by thermometer, when placed at the hottest accessible spot, shall be the subject of special agreement, but it shall in no case exceed:

65°C if the windings are of Class A insulation,
80°C if the windings are of Class E insulation,
90°C if the windings are of Class B insulation,
110°C if the windings are of Class F insulation, and
135°C if the windings are of Class H insulation.

A-1.3 Thermometer Method — In this method, the temperature is determined by thermometers applied to the accessible surfaces of the completed generator. The term thermometer also includes non-embedded thermocouples and resistance thermometers provided they are applied to the points accessible to the usual bulb thermometers.

When bulb thermometers are employed in places where there is strong varying or moving magnetic field, alcohol thermometers should be used in preference to mercury thermometers.

NOTE — The term 'accessible surfaces' is intended to convey that the established limits of temperature-rise of windings measured by thermometer are based on the use of thermometers placed on the external surfaces of the windings or iron cores with which the windings may be in contact. The measurements are not intended to cover readings which might be obtained by inserting thermometers into narrow interstices between coils, or between insulating flanges and coils. In such locations the temperature may be higher and allowance is made for this in fixing the permissible temperature-rises measured at the surface.

The fact that the type of construction renders a winding difficult of access is not to be taken as permission to operate such windings at higher temperatures than are allowed on those windings or portions of windings on which the thermometers can be more easily placed, and the standard limits of temperature-rise should not be exceeded on any winding surface. If a reasonable proportion of the windings is readily accessible to a thermometer, temperature-rise should be determined by a thermometer placed on these portions of the windings.

A-1.4 Resistance Method — In this method the temperature-rise of the windings is determined by the increase in the resistance of the windings.

A-1.4.1 *Determination of Temperature-Rise of Copper Windings from Increase in the Resistance* — The temperature-rise $t_2 - t_a$ may be obtained from the ratio of the resistance by the formula:

$$\frac{t_2 + 235}{t_1 + 235} = \frac{R_2}{R_1}$$

where

t_2 = temperature in °C of the winding at the end of the test,
t_a = temperature in °C of the ambient at the end of the test,
t_1 = temperature in °C of the winding (cold at the moment of the initial resistance measurement),
R_2 = resistance of the winding at the end of the test, and
R_1 = initial resistance of the winding (cold).

For practical purposes, the following alternative formula may be found convenient:

$$t_2 - t_a = \frac{R_2 - R_1}{R_1} (235 + t_1) + t_1 - t_a$$

When the temperature of a winding is to be determined by resistance, the temperature of the winding before the test, measured by thermometer, shall be practically that of the ambient.

NOTE — For materials other than copper, the figure 235 in the above formula should be substituted by the reciprocal of the temperature coefficient of resistance at 0°C for the particular material used.

APPENDIX B

(*Clause* 6.6.2.4)

METHOD OF TEMPERATURE CORRECTION FOR ALTITUDES AND AMBIENT

B-1. TEMPERATURE CORRECTION FOR ALTITUDE AND AMBIENT

B-1.1 Adjustment to Temperature-Rise to Take Care of Operating Conditions of Ambient Temperature and Altitude — This clause applies to generators dependent on cooling by air or other gas at atmospheric pressure where the temperature of the ambient when specified, is other than 40°C or where the altitude is greater than 1 000 metres.

Where the site altitude is greater than 4 000 metres, the correction for altitude shall be by agreement between the manufacturer and the purchaser.

The site conditions under which the provisions of **B-1.1.1** to **B-1.1.13** apply, are summerized in Table 2.

TABLE 2 CORRECTION OF TEMPERATURE-RISE FIGURES WITH ALTITUDE

(*Clause* B-1.1)

CONDITION	AMBIENT TEMPERATURE	ALTITUDE (METRES) 0 to 1 000 (Ref to Cl No.)	ALTITUDE (METRES) Above 1 000 and Up to 4 000 (Ref to Cl No.)
(1)	(2)	(3)	(4)
Site	Less than 30°C	B-1.1.4	B-1.1.10
	30°C to 40°C	B-1.1.2	B-1.1.11
	40°C	6.6	B-1.1.9
	40°C to 60°C	B-1.1.1	B-1.1.12
	Greater than 60°C	B-1.1.3	B-1.1.13
	Unspecified	—	B-1.1.8
Test	Within 30°C of site temperature	B-1.1.5	*
	Lower than site temperature by more than 30°C	B-1.1.6	*
	Higher than site temperature by more than 30°C	B-1.1.7	*

*Corrections for testing generators for operation above 1 000 metres are under consideration.

B-1.1.1 Where a generator is designed to operate with an ambient at a temperature exceeding 40°C but not exceeding 60°C, the permissible temperature-rises shall be reduced below the values given in Table 1 by the amount by which the specified or stated ambient temperature exceeds 40°C. The permissible correction factor shall be taken to the nearest whole Celsius degree.

B-1.1.2 Where a generator is ~~designed to~~ operate with an ambient at a temperature less than 40°C but not less than 30°C, the permissible temperature-rises may be increased above the values given in Table 1 by the amount by which the specified or stated ambient temperature is less than 40°C. The permissible rises shall be taken to the nearest whole Celsius degree.

B-1.1.3 Where a generator is designed to operate with an ambient at a temperature greater than 60°C, the permissible rises shall be by agreement between the manufacturer and the purchaser.

B-1.1.4 Where a generator is designed to operate with an ambient at a temperature less than 30°C, the permissible temperature-rises shall be increased above the values given in Table 1 by 10°C, unless otherwise agreed.

B-1.1.5 When the temperature of the ambient at the inlet to the generator during the temperature-rise test differs from that specified, or assumed from **B-1.1.8**, for operation on site by less than 30°C, no adjustment shall be made to the permissible temperature-rise on test.

B-1.1.6 When the temperature of the ambient at the inlet to the generator during the temperature-rise test is lower than that specified, or assumed from **B-1.1.8**, for operation on site by more than 30°C, the permissible temperature-rise on test shall be the permissible rise on site reduced by a percentage numerically equal to one-fifth of the difference in Celsius degrees.

B-1.1.7 When the temperature of the ambient at the inlet to the generator during the temperature-rise test is higher than that specified, or assumed from **B-1.1.8**, for operation on site by more than 30°C, the permissible temperature-rise on test shall be the permissible rise on site increased by a percentage numerically equal to one-fifth of the difference in Celsius degrees.

B-1.1.8 Where the ambient temperature at site is unspecified and the specified altitude is above 1 000 and up to 4 000 metres, the ambient temperature shall be assumed such that the reduced cooling resulting from altitude is compensated for by a reduction in ambient temperature. No adjustment to permissible temperature-rise in Table 1 shall, therefore, be made.

Table 3 shows to the nearest Celsius degree, some assumed ambient temperatures (based on a 40°C ambient below 1 000 metres). The decrease of temperature with altitude per 100 metres for each class of insulation is given in Table 4.

TABLE 3 ASSUMED AMBIENT TEMPERATURE

Altitude Metres	Ambient Temperature °C for Class of Insulation				
	A	E	B	F	H
(1)	(2)	(3)	(4)	(5)	(6)
1 000	40	40	40	40	40
2 000	34	33	32	30	28
3 000	28	26	24	20	15
4 000	22	19	16	10	3

B-1.1.9 Where the ambient temperature at site is specified as 40°C and the altitude is above 1 000 and up to and including 4 000 metres the reduction in permissible temperature-rises shall be as per Table 4 per 100 metres of altitude above 1 000 metres. In making the calculations it would be found convenient to use for each class of insulation, increments of altitude which correspond to 1°C, since this will avoid the inconvenience of applying fractional degree corrections to the various values of Table 1.

TABLE 4 TEMPERATURE CORRECTIONS FOR DIFFERENT ALTITUDE

(*Clauses* B-1.1.8 *and* B-1.1.9)

CLASS OF INSULATION (1)	DECREASE IN TEMPERATURE-RISE IN °C PER 100 METRES (2)	ALTITUDE INCREMENT IN METRES PER °C (3)
A	0·6	167
E	0·7	143
B	0·8	125
F	1·0	100
H	1·25	80

These increments are shown in Table 4. Parts of increments should be regarded as whole increments.

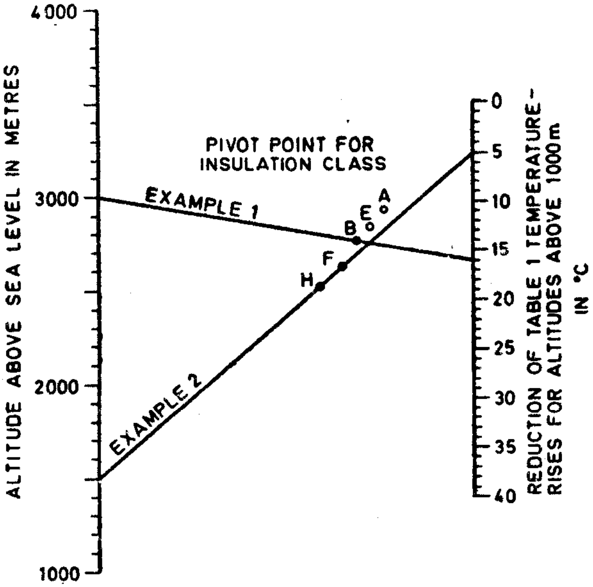
Alternatively the nomogram given in Fig. 1 may be used for this purpose, but in cases of dispute the corrections shall be calculated.

B-1.1.10 When a generator is designed to operate with an ambient at a temperature less than 30°C and at an altitude above 1 000 and up to 4 000 metres, the corrections specified in **B-1.1.4** and **B-1.1.9** shall both be applied.

B-1.1.11 When a generator is designed to operate with an ambient at a temperature between 30°C and 40°C and at an altitude above 1 000 and up to 4 000 metres, the corrections specified in **B-1.1.2** and **B-1.1.9** shall both be applied.

B-1.1.12 When a generator is designed to operate with an ambient temperature between 40°C and 60°C and at an altitude above 1 000 and up to 4 000 metres, the corrections specified in **B-1.1.1** and **B-1.1.9** shall both be applied.

B-1.1.13 When a generator is designed to operate with an ambient temperature greater than 60°C and at an altitude above 1 000 and up to 4 000 metres, the permissible temperature-rises will be by agreement between the manufacturer and the purchaser.



Example 1:

Altitude 3 000 m. Class B
Correction 16 deg C

Example 2:

Altitude 1 500 m. Class F
Correction 5 deg C

NOTE 1 — Nomogram indicate corrections to be made to temperature-rises in Table 1 due to site altitude above sea level in accordance with **B-1.1.9** to be read to the nearest whole degree upwards.

NOTE 2 — No correction is made between 0 and 1 000 m.

FIG. 1 NOMOGRAM

INDIAN STANDARDS INSTITUTION

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002
Telephones : 331 0131
331 1375

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices:

		Telephone
*Western	: Manakalaya, E9 MIDC, Marol Andheri (East) BOMBAY 400093	6 32 92 95
†Eastern	: 1/14 C. I. T. Scheme VII M V.I.P. Road, Maniktola CALCUTTA 700054	36 24 99
Northern	: SCO 445-446, Sector 35-C CHANDIGARH 160036	2 18 43 3 16 41
Southern	: C. I. T. Campus MADRAS 600113	41 24 42 41 25 19 41 29 16

Branch Offices:

'Pushpak', Nurmohamed Shaikh Marg, Khanpur AHMADABAD 380001	2 63 48 2 63 49
F' Block, Unity Bldg, Narasimharaja Square BANGALORE 560002	22 48 05
Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar BHOPAL 462003	6 67 16
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
53/5 Ward No. 29, R. G. Barua Road, 5th Byelane GUWAHATI 781003	—
5-8-56C L. N. Gupta Marg, HYDERABAD 500001	22 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
Hantex Bldg (2nd Floor), Rly Station Road, TRIVANDRUM 695001	52 27

Inspection Office (With Sale Point):

Institution of Engineers (India) Building, 1332 Shivaji Nagar PUNE 411005	5 24 35

---

*Sales Office in Bombay is at Novelty Chambers, Grant Road BOMBAY 400007 — 89 65 28

†Sales Office in Calcutta is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072 — 27 68 00

Reproduced by Reprography Unit, ISI, New Delhi